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FUEL REQUIREMENTS FOR AUTOMOBILE ENGINE STARTING

The third major project of the fuel research, which has been carried on at this bureau since 1922 in cooperation with the automotive and petroleum industries, was a study of the fuel requirements for automobile engine starting. This particular investigation was started in 1925 and completed during 1926. It comprised (1) extensive engine tests to ascertain the time required to start an automobile or truck engine and the amount of fuel used for that purpose under various conditions of temperature, mixture supplied, cranking speed, etc., using various fuels; and (2) laboratory tests of the volatility of the same fuels.

When the results of the engine tests and of the laboratory tests were analyzed, it was found possible to establish a direct relation between engine-starting performance and the fuel volatility data. The laboratory volatility test which comes nearest to representing actual conditions as they exist in the engine manifold is the equilibrium air distillation. In this test measured amounts of air and liquid fuel are supplied at a constant rate to an evaporating coil which is maintained at constant temperature, and the rate of collection of unevaporated fuel is measured. This gives, by difference, the percentage of the fuel which will evaporate at a definite temperature when mixed with air in a definite proportion. It was found that when resultant fuel-air ratios, obtained in equilibrium air distillations with the same mixture ratio supplied and the same temperatures employed in the engine tests, were plotted against the number of engine revolutions required to start, all the results could be represented by a single curve. Hence, the resultant fuel-air ratio alone determines the number of revolutions required to start, the effects of different fuels, different temperatures, etc., appearing only as they affect the resultant fuel-air ratio.

The amount of cranking required to start any engine on a given fuel at a given temperature appears to depend on the richness of the mixture supplied at the carburetor and the percentage of the fuel which can be evaporated in such a mixture at the given temperature. The fuel requirements for engine starting have been defined (tentatively) as follows: (1) Possible starting with a 1:1 mixture supplied at the lowest temperature ever anticipated, and (2) starting in 10 engine revolutions with 1:2 fuel-air mixture supplied at the average (daily) minimum temperature encountered in service. These definitions serve to fix the percentage of the fuel which must be evaporated at each of the temperatures in equilibrium air distillations; namely, 5 per cent in a 1:1 mixture and 15 per cent in a 1:2 fuel-air mixture supplied. For each of nine fuels studied the ratios of the absolute temperatures corresponding to 5 per cent evaporated in the standard American Society for Testing Materials distillation and in the equilibrium air distillation are practically constant and the same result is found in the case of 15 per cent evaporated. Thus, it becomes possible to interpret the results of the engine-starting tests directly in terms of the A. S. T. M. distillation curves of the fuels used. The following conclusions have been reached:

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1. Fuel requirements for engine starting depend largely on the temperatures anticipated in service. These temperatures may be obtained for any given locality from United States Weather Bureau statistics.

2. Two points on the standard A. S. T. M. distillation curve appear to be an adequate means of specifying the fuel to meet given requirements. Conversely, these points on the distillation curve serve to determine the temperatures at which a given fuel is most suitable for engine starting.

3. A knowledge of the fuel requirements for each season in any locality and two points on the distillation curve for a given fuel appear sufficient to determine whether the fuel is better or worse than is required for starting.

4. If the fuel is better than required, excessive evaporation losses in production and distillation constitute unnecessary waste. If the fuel is worse than required, excessive consumption during starting would appear to constitute avoidable waste.

CONSTANT TEMPERATURE-HUMIDITY BOX FOR THE STORAGE OF CEMENT TEST SPECIMENS

The surrounding temperature and humidity during the first 24 hours after making affect the properties of cement and mortar test specimens. For this reason, and to conform to the American Society for Testing Materials' temperature requirements of $70°\pm5°$ F., a constant temperature and humidity storage box has been developed and put into successful operation at the bureau. Because of the high humidity required, as near to the saturation point as possible to attain, the design of a reliable type of apparatus is exceedingly difficult. A large size refrigerator, 40 cubic feet capacity, was selected for the box proper. Cooling is obtained by a two-cylinder compressor driven by a one-fourth horsepower motor, with SO_2 as the refrigerating medium. The expansion coils are in the box. Heat is supplied by a nichrome resistance coil in the box. A one-fourth horsepower motor driving a one-stage centrifugal pump circulates the water. The bottom of the box forms a reservoir, the water being pumped and distributed around the top of the box by one-eighth-inch pipe with small drilled holes. This system is arranged to have the water flow down the sides and two inner partitions. The inside of the box is covered with burlap to distribute and retard the water flow. The original louvers used as partitions were replaced by six mesh to the inch galvanized-wire screens. These form a very good path for the circulating water. A one-seventieth horsepower motor drives a blower to circulate the air in the box.

The wet and dry bulb recording thermometers have a slight temperature error because the thermometer proper is of necessity mounted on the outside of the box. A mercury regulator in connection with a control device completes the list of auxiliary apparatus. To eliminate sparking and fouling of the mercury, the device developed by D. J. and J. J. Beaver and described in the article "A new method for the control of thermostats," J. Ind. and Eng. Chem., Vol. 15, p. 359 (April, 1923), was modified and applied. Incandescent lamps operating much below their normal voltage are used for resistance, and the relay of the Beaver apparatus is used to operate a second alternating-current relay which throws the heater or refrigerator into operation. To simplify the control apparatus, the heating and cooling effect were so arranged that either one or the other operates. It is theoretically more efficient to have a neutral zone with a small range with neither heating or cooling effect, but this would require a control apparatus many times more complicated, with the resulting greater liability to breakdown more than counterbalancing the advantages.

ADHESION OF MORTAR TO SAND-LIME BRICK

A considerable number of tests have been made at the bureau on the adhesion of mortar to sand-lime brick. The program included a study of different fac-

tors influencing the results, such as the kind of mortar, the percentage of water in the brick when used, the consistency of the mortar, and percentage of water absorbed in a definite time, as well as different storage conditions. Especial attention has been given to the subject of the percentage of water absorbed per unit of time and its effect upon the results. No attempt has been made to evaluate the quality of the workmanship, the aim being to get a good contact of mortar and brick regardless of the rates of absorption.

The tests on the effect of different percentages of water taken up by the bricks in a definite period were made on six makes of sand-lime bricks. One make of sand-lime bricks was divided into groups according to the amount of water absorbed through one side in one hour. Bricks within the groups which absorbed 1.5, 2.5, and 3.5 per cent of water were mortared together with 1:3 cement mortar by weight, containing 23 per cent water. The adhesion of the mortar to the brick in these joints in 28 days was 18, 27, and 38 lbs./in.^{2}, respectively. (These results were the averages of 10 joints of each.) The ranges in the amounts of water absorbed in one hour through one side of the bricks of two groups of another make of sand-lime brick were 11.7 to 23.3 per cent, and 3.2 to 8 per cent; the adhesion of the mortar to the bricks in these groups was 35 and 18 lbs./in.^{2}, respectively. Similar results were obtained with the four other makes of sand-lime bricks. The conclusion is that where the entire faces of both bricks are brought in contact with the mortar while it is sufficiently wet, greater adhesion is obtained with bricks of high than with low water absorption when immersed as outlined above. The probable explanation is that the more absorptive bricks draw water out of the mortar more rapidly than the less absorptive bricks; that some cement is brought into the surface pores by this action; and that the mortar becomes denser as a result of tapping the bricks with the handle of the trowel while the water is being absorbed.

It was found that manufacturers use different sands, and that the resulting surface texture of their bricks differs. This difference in texture of a brick is an important factor, which probably accounts for the fact that different makes of bricks used with the same mortar develop different degrees of adhesion to the mortar, although their percentage absorption may be the same.

Further tests are to be made with bricks that have received different percentages of water before use, for many bricks are too absorptive to be used dry with good results.

PHYSICAL PROPERTIES OF HEAVY CLAYS

In August, 1926, the Columbus branch of the bureau began an extensive investigation with the object of determining the properties which are characteristic of the several types of clays employed in the heavy-clay industries. After consultation with Professor Stout, of the Ohio Geological Survey, 11 shales and 8 alluvial clays were selected for experimentation in the first phase of the work. A sample weighing approximately 1,500 pounds of each of the clays and shales was obtained and sent to Columbus, where the samples were dried, ground, and quartered to uniformity.

The alluvial clay from Rutland, Ohio, was selected for some preliminary experiments designed to show which of several different methods would be most desirable to use in making the various test pieces from the several shales and clays. Test pieces were made by the following processes:

1. Dry press, using 10 per cent water and a hydraulic press.
2. Stiff mud, using 32 per cent water and a brass mold.
3. Slop mold, using 65 per cent water and a plaster mold.
4. Cast, using 133 per cent water and a plaster mold.
5. Stiff mud, using 26, 30, and 37 per cent water and an auger machine.

From transverse strength and porosity values on the bone-dry test pieces it was apparent that the dry press and casting processes are capable of producing the

greatest uniformity among the various test pieces. The test pieces made by the auger machine showed increasing strength with increasing water content, the modulus of rupture being 158 lbs./in.^{2} for the bars tempered with 26 per cent water and 234 lbs./in.^{2} for those tempered with 37 per cent water. The porosity was 39 and 36 per cent, respectively, for the bars tempered with 37 and 26 per cent water. The bars made by the stiff mud process with the brass mold were decidedly stronger than those made by the other processes, being 428 lbs./in.^{2}. However, owing to convenience of preparation and the fact that the stiff mud auger-machine method will yield data which can be more readily translated into terms of the heavy clay industry, it was decided to prepare all future test pieces by the auger-machine method.

ELECTRICAL PROPERTIES OF RUBBER-SULPHUR COMPOUNDS

The results of an investigation of the electrical properties and the density of compounds of rubber and sulphur are being prepared for publication. These results are of interest, not only in so far as they relate to practical soft rubber and hard rubber insulation, but also in that they shed light on the nature of the reaction of rubber with sulphur. The dielectric constant of rubber increases with the proportion of combined sulphur up to 10.5 per cent; at this point it has a maximum value which is about one and one-half times that of crude rubber. The dielectric constant then decreases with increasing sulphur content and passes through a minimum at 19 per cent of sulphur, at which composition the value is only 10 per cent greater than that of crude rubber. The value increases only 5 per cent as the composition changes from 19 to 32 per cent of combined sulphur. The power factor bears a similar relation to composition except that its maximum value occurs, not at 10.5 per cent of sulphur but at 13.5 per cent. There is a minimum value at 19 per cent of sulphur, and then an increase from 19 to 32 per cent of sulphur, just as in the case of the dielectric constant. The maximum value of the power factor is about 7 or 8 per cent, which amounts to about a thirty-fold increase over that of crude rubber. The resistivity-composition curve is not very sharply defined on account of rather wide variations between individual determinations. There are, however, inflections corresponding approximately to the compositions 10.5, 13.5, and 19 per cent of combined sulphur. The curve goes through a maximum at about 26 per cent of combined sulphur, and there is a decrease from this composition to 32 per cent of sulphur.

Density measurements show that a relatively large decrease in volume accompanies the reaction of rubber with sulphur. When molecular volume is plotted against composition, a large and distinct change occurs at 19 per cent of sulphur. The data are not sufficiently accurate to determine whether smaller and less pronounced changes occur at other compositions.

The significant feature of these results is that different properties show discontinuities or changes at the same compositions, and that these compositions may be represented by simple formulas. This is best shown by the summary given in the accompanying table.

The data shown in the table present strong evidence for the existence of a compound having the empirical formula, $(C_5H_9)_2S$, and less conclusive evidence for the existence of three other compounds, $(C_5H_9)_4S$, $(C_5H_9)_2S_2$, and $(C_5H_9)_4S_2$.

When the electrical properties and the density of vulcanized rubber are plotted against the percentage of combined sulphur, curves are obtained which show points of inflection at definite compositions. This table indicates the manner in which the slopes of these curves change at the points of inflection.

Composition, sulphur	Empirical formula	Molecular volume	Dielectric constant	Power factor	Resistivity
10.5	$(C_8H_9)_4S$		Maximum		Small change.
13.5	$(C_8H_9)_3S$ [1]			Maximum	Do.
19	$(C_8H_9)_2S$	Large change	Minimum	Minimum	Do.
26	$(C_8H_9)_4S_3$				Maximum.

[1] Equivalent to $(C_8H_9)_4S$. $(C_8H_9)_2S$.

STABILIZATION OF GOLD-PLATED WEIGHTS

As reported a few months ago (T. N. B. No. 115, Nov., 1926), many gold-plated weights of the common screw-knob type have been found to change by excessive amounts with changes in the humidity of the atmosphere. The cause of this seems to be the presence of salts or corrosion products from the electroplating liquid or from other solutions used in the preparation of the weights.

Experiments with a number of sets from different makers have now shown that this trouble can be avoided by thoroughly washing and boiling the weights in water, if the knobs are removed and sufficient attention is given to the washing of the cavity. In this boiling it is preferable to change the water more than once, unless a very large quantity of water is used.

Completed sets that show this excessive variability can be stabilized by the same process, though this will require that the weights be readjusted. If practicable, the adjusting material should be removed before the weights are boiled. If this is not done, there is danger that the work may not be successful. However, when the cavity appears very clean, except just at the top, it is worth while to do the boiling even if it is impracticable to remove the adjusting material. This is shown by the fact that the bureau boiled three such sets without removing adjusting material that had been pounded down in the bottom of the cavity, and in each case the excessive variability disappeared.

RECENT SCREW-THREAD AND GAUGE MEETINGS

On February 23 the National Screw Thread Commission held a meeting at the bureau, and the following program was discussed:

1. Report of cooperating committee on ground thread taps.
2. Report on instrument threads.
3. Report on pipe thread taps.
4. Report on Acme threads.
5. Small hose threads.
6. Flange bolts.
7. Minor diameter of not go ring gauges.
8. Minor diameter of nuts.
9. Threads for gas cylinders and metal drums.

A detailed report of the meeting has been prepared.

The Gauge Design Committee met at the bureau on February 24. This committee is an informal group comprising most of the large manufacturers and several large users of limit gauges and was organized at the request of the Ordnance Department of the Army. The purpose of the committee is to simplify and standardize the design of plain and threaded plug and ring limit gauges, to the end that greater economy in the production and use of gauges may result.

Up to this time attention has been given principally to plain and threaded plug gauges from ¼ inch to 1½ inches. Ring gauges covering the same size range are now being considered, and it is expected that the committee will extend its work to cover both larger and smaller gauges.

A meeting of the Gauge Steel Committee took place at the bureau on February 25. This committee is also an informal group comprising steel makers, gauge makers, and gauge users. Its purpose is the improvement of the dimensional permanence and wear resistance of limit gauges used in interchangeable manufacture. It has made an extensive

study of the problems of chemical composition and heat treatment of gauge materials with a view to increasing dimensional permanence and wear resistance of gauges.

The meeting on February 25 was devoted to the hearing of reports on wear tests being carried out at the bureau and to consideration of plans for continuing the work of the committee.

FOURTH ANNUAL MEETING, AMERICAN MARINE STANDARDS COMMITTEE

The fourth annual mass meeting of the American Marine Standards Committee was held at the Department of Commerce on January 17, 1927. The meeting was presided over by Col. E. A. Simmons, chairman of the executive board of the A. M. S. C. In his opening address the chairman pointed out that 26 standards were approved during the past year and, in addition, there was produced the report of the special committee on stability and loading of ships, representing the best thought of some of the prominent men in the marine field. The executive board for 1927, as recently elected by the membership, is made up of 21 prominent and representative men in the marine industry. Secretary Hoover addressed the meeting, stating that he considered the voluntary action of industry in the setting up of committees for the elimination of waste and the adoption of better methods was one of the most forward steps taken by the American business public in many years; that the purpose of the Department of Commerce was to encourage generally such action and to contribute directly to their deliberations wherever it was possible to so assist; that it was not the purpose of the department to dominate their decisions, for he held the belief that voluntary action was not only effective of far greater results than official pressure, but that it was laying the foundations for a much sounder economic organization for the country.

STANDARD CONTRACT FORM FOR FEDERAL SERVICE

In line with the movement to standardize commercial forms the Interdepartmental Board of Contracts and Adjustments, of the Bureau of the Budget, has developed standard contract forms. President Coolidge has recently approved the forms, consisting of an invitation for bids, a form of bid, instructions to bidders, a bid bond, and performance bond. He has directed that on and after January 1, 1927, these forms be used for every formal contract for the construction and repair of Federal buildings or works. The Contract Board first collected from the United States departments and establishments the contract forms in use and discovered there were several hundred of them varying in size, terms, and phraseology and embodying many unreasonable requirements.

This standard contract form will result in material saving to the Government and will make a large contribution toward more efficient and economical operation of the Federal service.

LABORATORIES EQUIPPED TO MAKE THERMAL EXPANSION TESTS

The bureau is preparing a list of laboratories equipped for making thermal expansion tests. In order to make this list as complete as possible, it is requested that laboratories in position to make tests for the public advise the bureau at an early date giving the following information, marking their replies "Attention of Thermal Expansion Laboratory":

1. Type of equipment used.
2. Type of material acceptable.
3. Dimensions of specimens required.
4. Temperature range covered.
5. Accuracy of determinations.
6. Fee schedule for representative tests.

The steady increase in requests for expansion tests at the bureau has increased the delay which necessarily occurs before a given test can be carried out and has made it impossible for the bureau to devote as much time as it should to researches in expensivity.

It is thought that many types of expansion tests can be carried out with sufficient accuracy by commercial laboratories and laboratories of educational institutions, thus permitting the bureau to complete more promptly such tests as are necessarily submitted to it, and at the same time to devote more time to research and development in the field of thermal expansivity.

DIRECTORY OF LABORATORIES AND CERTIFICATION PLAN

In accordance with the law, the National Bureau of Standards makes tests and carries out investigations for other Government departments. Because of the large amount of this official work it is impracticable for the bureau to make tests for private individuals if other laboratories can do the work. To inform interested persons of the location of other laboratories, and in anticipation of a marked increase in the demand for independent testing service in both domestic and export trade, the bureau has compiled a directory of the 207 commercial testing laboratories throughout the country, together with indications of the types of commodities

which they are prepared to test. Special care has been exercised to make this list complete. To accompany the list of testing laboratories there has also been compiled a list of the laboratories of 141 colleges which are used not only for the purposes of instruction but also to a considerable extent for research work. In fact, many important industrial research problems are being solved in the college laboratories. The directory has been sent to the printer, and will be available as a regular publication of the bureau.

The existence of a thoroughly classified list of testing laboratories will have a number of beneficial effects in promoting the use of specifications, not the least important of which will be the inducement offered to the large number of purchasers who have hitherto hesitated to buy on specifications because of their inability to determine whether or not commodities delivered correspond to the specification requirements.

For the purpose of minimizing the disadvantages incident to the use of specifications, the bureau has inaugurated a so-called "certification plan" in accordance with which there are compiled lists of manufacturers who have expressed their desire to supply material complying with certain selected nationally recognized specifications and willing to certify to the purchaser upon request that the material thus supplied is guaranteed to meet the requirements and tests of the specifications. This plan has already been applied to 48 United States Government master specifications. Copies of any of the 48 lists of manufacturers, to which additions are being made from time to time, can be obtained upon request.

STANDARDS YEARBOOK

There is now in press the first of a new type of publication to be issued annually in the miscellaneous series of the Bureau of Standards, and which will be known as Standards Yearbook.

The yearbook for 1926 covers all the essential elements of the standardization movement throughout the United States and incorporates the outstanding projects under consideration as international standards. This volume sets forth the fundamental national standards, such as standards of length, mass, volume, time, electromotive force, resistance, inductance, capacity, etc.

The Standards Yearbook will be most valuable in the daily work of all offices and agencies concerned with standardization, and since all industry is based more or less on standardization it should have a very wide application. The yearbook will inform purchasing agents of new standard specifications and will inform the scientist engaged in research as to current research projects which may lead to standardization. To the average reader it will prove a mine of information on the present status and trend of standardization in any field of industry, commerce, science, or Government, with references to sources of further information.

The book incorporates the authority, functions, procedure, and current activities of all national, State, municipal, and commercial organizations which are organized primarily for standardization work or with which standardization is an incidental activity. The current activities of the National Bureau of Standards, including the division of simplified practice, and division of building and housing, are set forth in some detail with particular regard to their relation to science, commerce, and industry.

Copies of the Standards Yearbook, known as M–No. 77, will be sold by the Superintendent of Documents, Government Printing Office, Washington, D. C., and it is expected that the book will be ready for distribution in about one month. The price has not yet been fixed, but will merely cover the cost of materials and printing.

NEW PUBLICATIONS

Additions to Supplementary List of Publications of the Bureau of Standards (beginning July 1, 1926).

Scientific Papers [1]

C288 (2d ed.). United States Government N. Ernest Dorsey. Price, 15 cents.

S542. Electric field of a charged wire and a slotted cylindrical conductor; Chester Snow. Price, 10 cents.

Circulars [1]

C288 (2d ed.). United States Government master specification for hose, tender (corrugated). Price, 5 cents.

C309. Gas-measuring instruments. Price, 40 cents.

C311. Stucco investigations at the Bureau of Standards with recommendations for Portland cement stucco construction. Price, 15 cents.

C318. United States Government master specification for matches, safety (full size, in boxes). Price, 5 cents.

[1] Send orders for publications under this heading, with remittance, only to Superintendent of Documents, Government Printing Office, Washington, D. C. Subscription to Technical News Bulletin, 25 cents per year (United States); 40 cents (foreign).

Building and Housing [1]

BH9. Recommended building code requirements for working stresses in building materials. Report of building code committee. Price, 10 cents.

Technical News Bulletin [1]

TNB119. Technical News Bulletin, March, 1927.

OUTSIDE PUBLICATIONS [2]

Recent work in geodetic tape standardization. L. V. Judson; National Research Council Bulletin No. 56; December, 1926.

Thermal expansion of graphite. Peter Hidnert and W. T. Sweeney (abstract); Physical Review, Vol. 29, p. 371; February, 1927.

The place of radio in aeronautics. J. H. Dellinger. National Aeronautic Association Review, Vol. 5, p. 3; January, 1927.

Simultaneous production of a fundamental and a harmonic in a tube generator. H. J. Walls; Proceedings Institute of Radio Engineers, Vol. 15, p. 37; January, 1927.

The cooperative fuel research to date. H. C. Dickinson; Journal, Society of Automotive Engineers; Vol. 20, No. 2, p. 193; February, 1927.

Fuel characteristics and engine starting. J. O. Eisinger and T. S. Sligh, jr.; Bulletin American Petroleum Institute, Vol. 8, No. 6, p. 143; January, 1927.

Measurement of consistency as applied to rubber-benzene solutions. W. H. Herschel and Ronald Bulkley; Proceedings American Society for Testing Materials; Vol. 26, Part II; 1926.

The tarnish resistance and some physical properties of silver alloys. Louis Jordan, L. H. Grenall, and H. K. Herschman; Mining and Metallurgy; March, 1927.

Laboratory tests on nonferrous screen wire cloth. G. W. Quick; Proceedings American Society for Testing Materials, Vol. 26, Part I, p. 492; 1926.

A preliminary study of the resistance to abrasion of ceramic glazes, its control and methods of determination. A. C. Harrison; Journal American Ceramic Society, Vol. 10, No. 2, p. 77; February, 1927.

Studies on the system CaO–Fe_2O_3–SiO_2. W. C. Hansen and R. H. Bogue; Journal American Chemical Society, Vol. 48, p. 1261; 1926.

The determination of uncombined lime in Portland cement. William Lerch and R. H. Bogue; Industrial and Engineering Chemistry, Vol. 18, p. 739; 1926.

A digest of the literature on the constitution of Portland cement clinker. R. H. Bogue; Concrete; July, 1926, to March, 1927 (serial form).

Portland cement research. R. H. Bogue; Proceedings American Society for Testing Materials, Vol. 26, Part II; 1926.

The preparation and optical properties of calcium hydroxide crystals. F. W. Ashton and Raymond Wilson; American Journal of Science, Vol. 13, p. 209; 1927.

The preparation of optically clear selenium for use in index media. L. T. Brownmiller; American Mineralogist, Vol. 12, p. 43; 1926.

Portland cement in concrete engineering. R. H. Bogue, Proceedings American Concrete Institute, Vol. 23; 1927.

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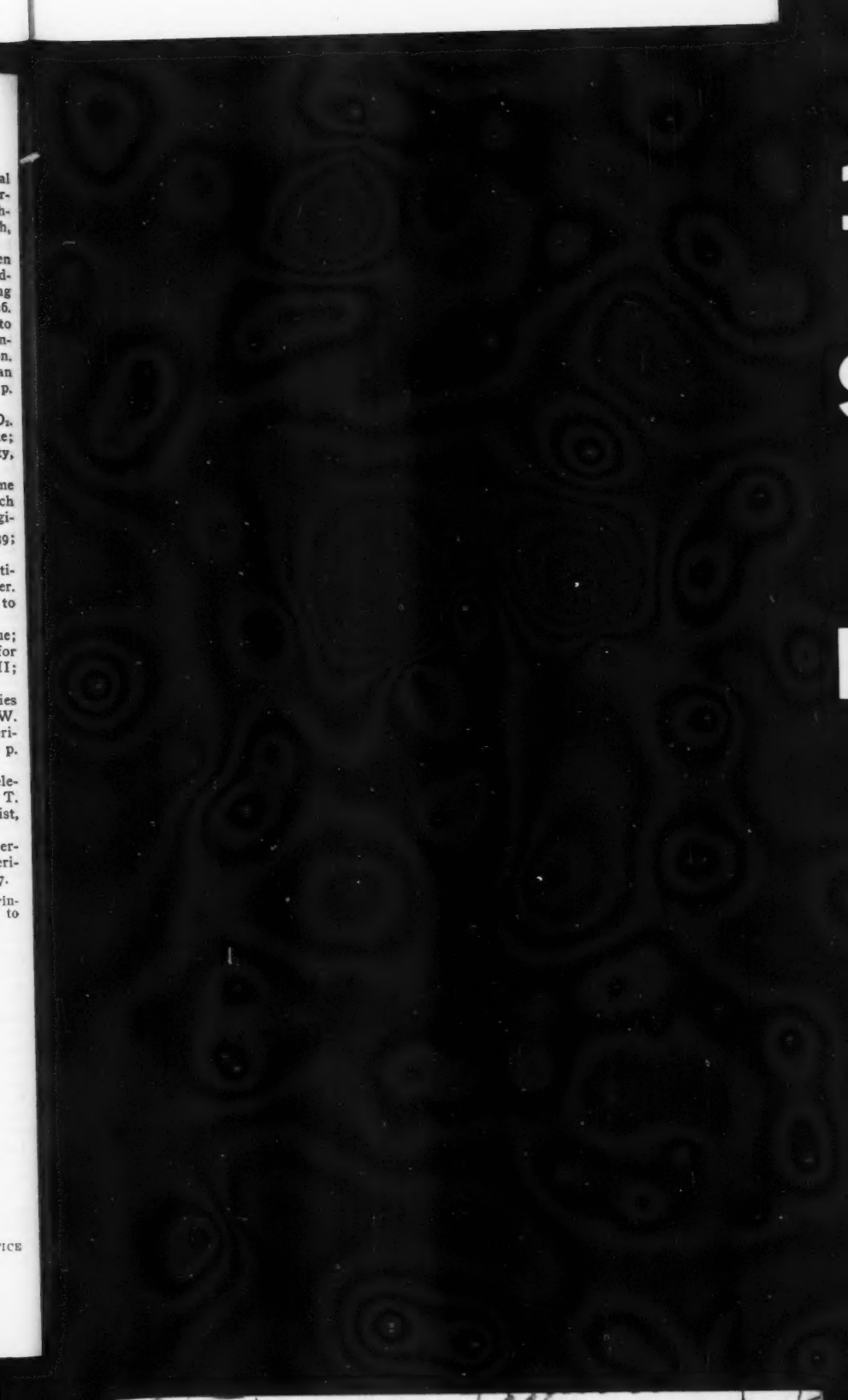
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